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MADRAS RECORD OFFICE.

Government of Madras.

Public works DEPARTMENT.

G.O. No. 3050 Press Mis.

9-10

Dated 1. 10. 1867.

Not to be folded or roughly handled

No. 9. Proceedings of the Government of India, Public Works Department, (Irrigation,) dated Simla, 26th August 1867, No. 128 I.

Record of volume of water which enters Canals of Irrigation, that which is utilized, and that which escapes.

Read the following papers:—

From the Secretary to Government of India, Public Works Department, to the Under Secretaries to the Governments of Punjab and North-Western Provinces, in the Public Works Department, (Irrigation Branch,) dated 11th June 1867, Nos. 71/2 I.

1. I am directed to request your attention to the necessity for recording systematically the volume of water which enters canals of irrigation, that which is utilized, and that which escapes.

2. For a proper control over the administration of any irrigation canal, it is essential that an exact knowledge of the actual quantity of water-supply shall be obtained. It would also appear proper that, where a canal is divided into two or more separate charges, a separate record of the volume of water entering, leaving, and utilized, should be obtained in each, so that the results of the operations in the several divisions shall be distinctly seen.

3. By suitable observations of the height of the water at various points on the canal, and the corresponding velocities, tables of discharge could be prepared for each locality, from which the required quantities could be got by mere inspection. In this manner, too, all doubts as to the loss by percolation, or gain by influx of local drainage, could be removed, and a fairly exact register of the actual volume of water passing down the canal might be secured.

4. There would seem to be no difficulty in making provision for the proper record of this class of facts, and I am to invite your attention to the subject with a view to early instructions being issued, under the orders of the Hon'ble the Lieutenant-Governor, for the preparation of registers of the nature referred to in all canals in the Punjab, (North-Western Provinces), should such an arrangement not have been already carried out.

5. For many reasons it will also be useful to have a record of the average monthly discharge in each division of every canal, distinguishing the quantities of water entering, leaving, and utilized, appended to the annual reports, and I am to request that the needful orders may be given to secure this information for the future.

From the Under Secretary to Government of North-Western Provinces, in the Public Works Department, (Irrigation Branch,) to the Secretary to the Government of India, Public Works Department, dated 10th August 1867, No. 559 I.

With reference to your letter No. 72 I of the 11th June last, I am directed to forward copy of a Note, No. 104C, dated 5th instant, by the Chief Engineer, Irrigation Works, North-Western Provinces, and its enclosures, concerning the record of discharge of canals, &c., and to intimate that His Honor the Lieutenant-Governor, North-Western Provinces, approves of the instructions issued by the Chief Engineer, and thinks that sufficient reason has been given for the adoption

of the ten-day interval in records of expenditure of water and of rain-fall, for the annual report. The principles on which the Chief Engineer has been working are clearly expressed in the 8th paragraph of his Circular No. 1,012, dated 19th January 1866, and appear to be correct.

Note by Chief Engineer, Irrigation Works, North-Western Provinces, concerning record of discharge of Canals, &c., dated 5th August 1867, No. 104 C.

REFERENCES :

A.—Memorandum No. 1,012 (Circular), dated 19th January 1866, from Chief Engineer, Irrigation Works, North-Western Provinces, to Superintending Engineers, Irrigation Works.

B.—Circular No. 169, dated 8th February 1866, from Superintending Engineer, 1st Circle, Irrigation Works, to Executive Engineers (with one enclosure, Reference A).

C.—Memorandum No. 11 (Circular), dated 2nd May 1866, from Chief Engineer, Irrigation Works, North-Western Provinces, to Superintending Engineers, Irrigation Works.

D.—Letter No. 72 I, dated 11th June 1867, from Secretary, Government of India, Public Works Department, to Under Secretary to Government, North-Western Provinces, (Irrigation Branch) Public Works Department.

ABSTRACT.

A.—Chief Engineer requests that Superintending Engineers and Executive Engineers will take every opportunity of obtaining data for the construction of tables of discharge for all rivers, streams, canals, rajbuhas, and water-courses, within the limits of their charges. Details the mode of construction of table of discharge.

Considers an Executive Engineer as responsible to Government for the proper economical employment of every cubic foot of water given into his charge as he is for every rupee of money.

Details the mode of arriving at the information required, including loss by escapes, and by evaporation and absorption, in canals, rajbuhas, and water-courses.

B.—Superintending Engineer circulates Chief Engineer's instructions as above, and adds further details.

C.—Chief Engineer issues instructions regarding the preparation of registers of water-gauges (*punsals,*) which are also to show the average discharge of every ten days, or third of a month.

D.—Secretary to Government of India calls attention to the necessity of recording systematically the discharge of canals, and asks that early instructions may be issued on the subject, if they have not been issued already.

REMARKS AND RECOMMENDATIONS.

References A to C show that the wishes of Government of India have been anticipated in the North-Western Provinces. A year and a half ago detailed instructions were issued to Superintending Engineers and to Executive Engineers concerning the preparation of tables of discharge, and the registration, every ten days, of the results for canals, as also instructions concerning similar tables for obtaining the discharge (minimum especially) of all rivers and streams.

2. Government of India desires that a record of the average monthly discharge and expenditure of water in each Executive Division of each canal shall be appended to Annual Reports.

3. Chief Engineer had at first intended to adhere to a monthly system, but he found that, in practice, the changes in agricultural operations, and in the weather, which frequently occur during a space of time so long as a month, made it necessary to fix on a shorter period; and he adopted the interval of ten days, or one-third of a month, as the longest that could advantageously be chosen, and as the most convenient in practice.

4. Tables of agricultural operations for each Executive Division have been prepared; and in them also the same period of one-third of a month has been adopted.

5. The amount of rain-fall, as measured by the nearest gauges throughout the division, should be given for the same intervals of time as the record of expenditure of water on irrigation in the Annual Report. There is often a very close connection between the rain-fall and the irrigation, but not always in the way that might perhaps be supposed. Heavy and general rain-fall may have the effect of causing a large extension of artificial irrigation immediately afterwards.

Memorandum from Chief Engineer, Irrigation Works, North-Western Provinces, to the Superintending Engineer, 1st Circle, Irrigation Works, North-Western Provinces, dated 19th January 1866, No. 1,012.

1. Chief Engineer requests that Superintending Engineer will take every opportunity himself, and through his Executives, of obtaining data for the construction of tables of discharge for all rivers, streams, canals, rajbuhas, and water-courses, within the limits of his charge.

2. A table of discharges consists of four columns, showing—

I.—The height of water on the gauge to tenths of a foot, from zero to the highest possible rise on the gauge.

II.—The corresponding area of water-section to hundredths of a square foot.

III.—The corresponding mean velocity of the current in lineal feet per second to hundredths of a foot.

IV.—The corresponding discharge in cubic feet per second to hundredths of a cubic foot.

3. The tables of discharge for artificial channels can be worked out theoretically in the first instance, and then checked and perfected gradually by observations made whenever an opportunity offers.

4. The position for the gauge should be chosen with care: for, unless the bed and banks of the stream remain practically permanent at, and for some distance above and below, that position, the height of water on the gauge can give no accurate data from which to compute the corresponding areas, velocities, and discharges.

5. Every gauge should have its "referring bench-mark" on some permanent building, or else specially built, out of the reach of injury from floods, &c., so that if the gauge be disturbed, or even carried away, it may speedily be replaced, or a new one set up with its zero on the same level as the old one.

6. Special care should be bestowed on the accurate registration of gauges in rivers and streams, at the season when they are lowest, or nearly so, and as it so happens that at this season the channel is not often altered by the action of floods, it is easy to compute the minimum discharge by the aid of the gauge register and one set of observations, which should always be taken when the river is as near its lowest state as can be conveniently managed.

7. In the case of artificial channels, silt is the great obstacle to accuracy of results being obtained from water-gauges. It may, therefore, be useful to know that, in ordinary soil, neither cutting nor silting takes place with a mean velocity of from two and a half to three feet per second, that is, when the silt is of the ordinary kind, and not either gravel or shingle. Accordingly, an endeavour should be made to place the water-gauge where the mean velocity of the current ranges between the given limits. This can seldom be managed on rajbuhas, except in the neighbourhood of a fall. A point, a little up-stream from the crest of an open fall, and beyond the influence of the acceleration of velocity due to its proximity, is not a bad place for a gauge. If, however, the natural level of the water is liable to be interfered with by planking up, or by any other artificial obstructions of irregular action, such a position should be avoided.

8. With regard to canals, &c., Chief Engineer holds that each Executive Engineer in charge of an irrigating work is as responsible to Government for the proper economical employment of every cubic foot of the water given into his charge, as he is for every rupee of Government money which passes through his hands; and the keeping up of an account current (as it were) showing the

half-yearly receipts and expenditure of water, is as essential as the keeping up of his Cash-book, But without water-gauges and corresponding tables of discharges, he cannot arrive at a knowledge of either his receipts or his expenditure ; and, consequently, both he and Government must remain in the dark as to the real results of his administration.

9.—The observations most immediately requiring registration are—

I.—For the supply entering the division ; and

II.—For the supply passed of both to the division next lower down (if there be one) and through tails and escapes ;

and the Chief Engineer requests that Superintending Engineer will arrange to have this information obtained with regularity and with accuracy.

10. The difference between the aggregates of I and II will, of course, give the total expenditure of water in the division. This total expenditure is made up of—

A.—The loss in the canal itself by evaporation and absorption,

B.—The loss in rajbuhas,

C.—The loss in water-courses, and

D.—The actual expenditure of water in irrigation.

And it is evident that it is the duty of the Executive Engineer to reduce the three items, A, B, and C, to the very lowest ; but it is impossible for him even to know whether the measures he may adopt for this purpose are at all successful unless he has the means of recording and of comparing actual quantities.

11. Government of India has lately called for statistics of rajbuhas to be furnished annually, and the Chief Engineer has submitted a form for approval, and an application for the means of filling it in (establishment) if approved of. This will give us—

III.—The supply issued from the canal through rajbuha heads, and

IV.—The supply passed off to rajbuhas lower down (if there be any), and through rajbuhs, tails, and escapes.

12. The difference between the aggregates of I, and of the sums of II and III, will give us at once A, the loss in the canal itself by evaporation and absorption combined ; and the difference between III and IV will give the sum of the items B, C, and D, with which, I fear, we must be content for the present, that is, until we can arrive at a fair approximation to the discharge of "kolabas," or water-course heads.

13. The first thing, however, to be done is, to fix I and II, as explained in paragraph 9.

Memorandum from Superintending Engineer, 1st Circle, Irrigation Works, North-Western Provinces, to the Executive Engineer, Ganges Canal Division, dated 8th February 1866.

Circular No. 169.

1. Forwards, for information, copy of letter No. 1,012 of 19th ultimo, from the Chief Engineer, Irrigation Works, North-Western Provinces, on the subject of taking discharges.

2. The discharge of rajbuhas will be noticed hereafter, as soon as orders are received from the Government of India, but in the meantime, steps may be taken for ascertaining the discharge of the canal with varying supplies of water. These discharges should be taken through a range of two feet on the gauge at difference of one-tenth of a foot. Thus, supposing the highest measure on the gauge is six feet nine inches, the discharges should be shown for every decimal of a foot from seven feet to five feet, or even lower, if the gauge ever falls below that point. It is not wished to give unnecessary trouble by ascertaining the discharge from zero to full supply, but merely within the limits of fluctuation of the gauge, providing for all contingencies.

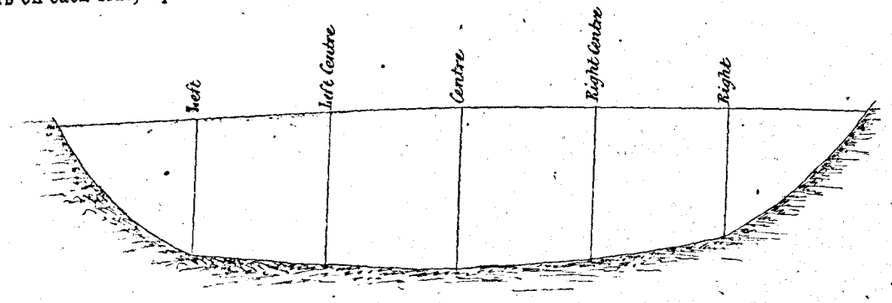
3. As it would greatly delay the preparation of the return if it were retarded till observations could be taken for each decimal of a foot, it will be necessary in the first instance

merely to make one or two observations with a known height of gauge, and from these to calculate theoretically the discharge due to the remaining ; the rule to be used will be $V = 90 \frac{\sqrt{R}}{S}$, where V = mean velocity in feet per second, R = hydraulic mean depth, and S = length in which fall is one foot ; as the term S will be difficult of determination under present conditions of the canal, it will not be possible to deduce discharges except on the basis of one observation ; but the discharge being observed for a given height of gauge, all others can be deduced readily, as the velocities will vary as $\sqrt{R}$; the other terms remaining constant. The drawing out of a table, therefore, will be comparatively easy.

4. In order to ascertain the discharge by actual observation, a spot as near as possible to an existing *punsal* should be selected, where the disturbance of bank and bed has been only slight. At this point, the section of channel should be taken by measurement, the depths being ascertained at equal intervals, say, at every 5 feet of width. If the section of the prolongation of the banks above water surface is also given, this one section will do for all the calculations or observations at this spot. The section, being obtained, will admit of the area and wetted perimeter being ascertained, whence the hydraulic mean depth can be deduced.

5. A distance of 100 feet, both above and below the site of section, should be measured along the canal bank, and strong pegs be driven into it at these points, thus giving a total length 200 feet, with the measured section in the centre. Two similar pegs should also be driven on the other bank of the canal opposite to the two first described.

6. The time of floatation of a light body will then be observed along this distance in seconds by means of a watch, which will determine the surface velocity, which multiplied by ·81 will give the mean velocity, and this latter multiplied by section of water, will give discharge in cubic feet per second. This timing must be taken in five points in the channel : one in the centre, and two others on each side, equi-distant between it and the bank, thus—



Five observations of velocity will be made at each point, thus giving 25 in all, the mean of which will show the average surface velocity at the point where the section is.

7. The first point is to stretch a rope tightly across the channel, marked off in 5 feet lengths by a 10-foot rod, pieces of colored cloth being tied at each 5 feet. Then with a boat, the depths at each of these points can be ascertained, which will give the section of the canal.

8. For timing the velocity, the simplest float will be a piece of "oopla," with a patch of whitewash on it, so as to make it easily distinguishable. Four flags should then be stuck up at the four pegs, and a man stationed at the upper and lower flags on the bank on which the Officer is ; the float will then be let go where it is required, a little above the upper flag, so that it may acquire the velocity of the current before reaching that spot. On passing the flag, the man stationed there will cry out, and the Officer will note the time, and in passing the lower flag, the signaller there will likewise call out, and the time will be noted, from which the time of floatation will be ascertained, and the velocity per second can be deduced. The pegs should be left permanently in the banks, so that, in subsequent observations all that will be necessary will be to take the time of floatation between them, the section varying merely with the depth of water. It is requested that orders be issued that every Officer be directed, whenever he visits the spot,

to take the velocity by actual observation ; this will verify previous observations if the gauge is the same, or determine new velocities for any variation that may exist.

9. The annexed form of table is to be adopted ; the first entry being the result of actual observations, from which the table can be completed in the first instance by results obtained from it as a datum ; the column of actual or observed discharges being left blank to be filled up hereafter as observations may enable it to be done. As soon as the table is filled with calculated discharges, a copy will be sent to this Office, and all future observations will be reported in order that it may be completed as information is gained.

10. In each division, these observations should be made as near the head as possible, above the first set of rajbuhas, and at the tail below the last set of rajbuhas, so that on knowing the discharge at both head and tail during the month, the expenditure of the division can be deduced.

11. In order, however, to ascertain correctly the expend ture in divisions, some corrections will be necessary ; for instance, if escapes are opened, a similar procedure must be adopted for ascertaining their discharges, and in case of rajbuhas of a lower division being taken off above the lowest gauge of the division, their discharges must be entered, and be deducted from the total of the division. In the Revenue Report of the division for each half-year, the following information will be given :—

			C. ft. per second.
Discharge at head (Myapoor), average gauge	4·76	feet	= 5,220
Discharge at tail (Jaolee), ,, ,,	5·20	,,	= 4,540
Difference ...			680

Deduct loss by escapes	C. ft. per second.
Right rajbuha, Meerut division, at Jaolee fall	0
Left rajbuha, Futtehgurh ,, ,, ...	45
	50
	— 95
Total ...	585
Add right rajbuha taken out from (next above) division...	0
Left ,, ...	0 0
Total ...	585

12. It is requested that great care may be taken in the preparation of the return of water expenditure in each division, as required. It may happen that local circumstances may make alterations necessary, but the above general instructions will show Officers what is required. The actual discharges of the canal must, however, be taken at once, and the table filled in the annexed form :—

Discharges of Ganges Canal (at Roorkee.)

Height of gauge, feet.	Area of section, square feet.	Hydraulic mean depth, feet.	By observation.		Discharge, cubic feet per second.	By calculation.	
			Surface velocity V, feet per second.	Mean velocity. ·81 V, feet per second.		Mean velocity feet per second.	Discharge, cubic feet per second.
	1	2	3	4	5	6	7
7·							
6·9							
6·8	1,295·21	6·46	4·12	3·335	4,316·89	...	...
&c.							
6·4							
&c.	1,224	6·15	...	...	...	3·25	3,986·56
6·0							
5·9							
5·8	1,147·5	5·82	...	...	...	3·16	3,630·69
&c.							
5·							

Columns 1 and 2 can be filled in at once on sections being taken; 3, 4 and 5 will be filled as observations allow.

Columns 6 and 7 can be calculated, and should be filled in on calculation at once, and they will be verified by the entries of 3, 4, and 5, as they are obtained.

—

Memorandum from Chief Engineer of Irrigation Works, to the Superintending Engineers, 1st and 2nd Circles, Irrigation Works, N. W. P., dated 2nd May 1866, Nos. 11, 12.

1. Requests that the punsauls in his Circle may be registered and sent in on sheets holding ten days (or one-third of a month) each, that is the first interval of each month to be from 1st to 10th inclusive, the second from 11th to 20th, and the third from 21st to end of month.

2. At the top, the full supply punsaul to be written with the corresponding discharge under it, and at the bottom the average-supply punsaul for the ten days, with the corresponding discharge under it, as follows :—

Full supply	5·60 / 2,060
1st	0·00
2nd	0·00
3nd	0·00
4th	0·00
5th	0·00
6th	0·00
7th	0·00
8th	0·00
9th	0·00
10th	0·00
Average	4·32 / 1,485

—

From the Secretary to Government of India, Public Works Department, to the Under Secretary to Government of North-Western Provinces, in the Public Works Department, (Irrigation Branch,) dated 26th August 1867, No. 127 I.

I am directed to acknowledge receipt of your letter No. 559 I of 10th August 1867, and to state that the Governor General in Council entirely approves of the action taken, and instructions issued, by the Chief Engineer of Irrigation Works in the North-Western Provinces, in the matter of keeping a record of the discharge, &c., of canals of irrigation.

—

ORDER.—Ordered that copies of these papers be forwarded, for information, to the Governments of Madras, Bombay, Bengal, and the Punjab.

(Signed) W. McCLEERY, C. E.,
Offg. Asstt. Secy. for Secy. to the Govt. of India.

Proceedings of the Madras Government, Public Works Department,
1st October 1867.

No. 10. ORDER THEREON, 1st October 1867, No. 3,050.

IRRIGATION, No. 1.

Communicated to the Superintending Engineers for information.

(True Extract.)

(Signed) J. H. M. SHAW STEWART, Major, R. E.,
Under Secretary to Government.

To the Superintending Engineers.

Exd. S. T. Augustin.

Enclosure to Public Works Nos. 128—31 *I of* 1867.

Nos. 71—2 I, dated 11th June, 1867.

From—COLONEL C. H. DICKENS, R. A., *Secy. to Govt. of India, P. W. Dept.,*
To—*Under Secretaries to Govts. of Punjab and N. W. P., in the P. W. Dept., Irrign. Branch.*

I am directed to request your attention to the necessity for recording systematically the volume of water which enters canals of irrigation, that which is utilized, and that which escapes.

2. For a proper control over the administration of any irrigation canal, it is essential that an exact knowledge of the actual quantity of water-supply shall be obtained. It would also appear proper that, where a canal is divided into two or more separate charges, a separate record of the volume of water entering, leaving, and utilized, should be obtained in each, so that the results of the operations in the several divisions shall be distinctly seen.

3. By suitable observations of the height of the water at various points on the canal, and the corresponding velocities, tables of discharge could be prepared for each locality, from which the required quantities could be got by mere inspection. In this manner, too, all doubts as to the loss by percolation, or gain by influx of local drainage, could be removed, and a fairly exact register of the actual volume of water passing down the canal might be secured.

4. There would seem to be no difficulty in making provision for the proper record of this class of facts, and I am to invite your attention to the subject with a view to early instructions being issued, under the orders of the Hon'ble the Lieutenant Governor, for the preparation of registers of the nature referred to in all canals in the Punjab N.W.P., should such an arrangement not have been already carried out.

5. For many reasons it will also be useful to have a record of the average monthly discharge in each division of every canal, distinguishing the quantities of water entering, leaving, and utilized, apppended to the annual reports, and I am to request that the needful orders may be given to secure this information for the future.

No. 559 I, dated 10th August, 1867.

From—LIEUT.-COL. J. H. DYAS, R. E., *Under Secy. to Govt. of N. W. P., in the P. W. Dept., Irrign. Branch,*

To—*Secretary to Government of India, P. W. Dept.*

With reference to your letter No. 72 I of the 11th June last, I am directed to forward copy of a Note, No. 104 C, dated 5th instant, by the Chief Engineer, Irrigation Works, North Western Provinces, and its enclosures, concerning the record of discharge of canals, &c., and to intimate that His Honour the Lieutenant Governor, North Western Provinces, approves of the instructions issued by the Chief Engineer, and thinks that sufficient reason has been given for the adoption of the ten-day interval in records of expenditure of water and of rain-fall, for the annual report. The principles on which the Chief Engineer has been working are clearly expressed in the 8th para. of his Circular No. 1012, dated 19th January 1866, and appear to be correct.

No. 104 C, dated 5th August, 1867.

Note by LIEUT.-COL. J. H. DYAS, R. E., *Chief Engineer, Irrigation Works, N. W. Provinces, concerning record of discharge of Canals, &c.*

REFERENCES:

A.—Memorandum No. 1012 (Circular), dated 19th January 1866, from Chief Engineer, Irrigation Works, North Western Provinces, to Superintending Engineers, Irrigation Works.

B.—Circular No. 169, dated 8th February 1866, from Superintending Engineer, 1st Circle, Irrigation Works, to Executive Engineers (with one enclosure, Reference A).

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No. 1012, dated 19th January, 1866.

Memo. from—LIEUT.-COL. J. H. DYAS, R. E., *Chief Engr., Irrgn. Works, N. W. Provinces,*

To—Superintending Engineer, 1st Circle, Irrigation Works, N. W. Provinces.

Chief Engineer requests that Superintending Engineer will take every opportunity himself, and through his Executives, of obtaining data for the construction of tables of discharge for all rivers, streams, canals, rajbuhas, and water-courses, within the limits of his charge.

12. The difference between the aggregates of I, and of the sums of II and III, will give us at once A, the loss in the canal itself by evaporation and absorption combined; and the difference between III and IV will give the sum of the items B, C, and D, with which, I fear, we must be content for the present, that is, until we can arrive at a fair approximation to the discharge of "kolabas," or water-course heads.

13. The first thing, however, to be done is, to fix I and II, as explained in para. 9.

Circular No. 169, dated 8th February, 1866.

Memo. from—MAJOR T. G. GLOVER, R. E., *Supdg. Engr. 1st Circle, Irrigation Works, N. W. Provinces,*

To—Executive Engineer, Ganges Canal Division.

Forwards, for information, copy of letter No. 1012 of 19th ultimo, from the Chief Engineer, Irrigation Works, North Western Provinces, on the subject of taking discharges.

2. The discharge of rajbuhas will be noticed hereafter, as soon as orders are received from the Government of India, but in the mean time, steps may be taken for ascertaining the discharge of the canal with varying supplies of water. These discharges should be taken through a range of 2 feet on the gauge at difference of one-tenth of a foot. Thus, supposing the highest measure on the gauge is 6 feet 9 inches, the discharges should be shown for every decimal of a foot from 7 feet to 5 feet, or even lower, if the gauge ever falls below that point. It is not wished to give unnecessary trouble by ascertaining the discharge from zero to full supply, but merely within the limits of fluctuation of the gauge, providing for all contingencies.

3. As it would greatly delay the preparation of the return if it were retarded till observations could be taken for each decimal of a foot, it will be necessary in the first instance merely to make one or two observations with a known height of gauge, and from these to calculate theoretically the discharge due to the remaining; the rule to be used will be $V = 90 \frac{\sqrt{R}}{S}$, where V = mean velocity in feet per second, R = hydraulic mean depth, and S = length in which fall is 1 foot; as the term S will be difficult of determination under present conditions of the Canal, it will not be possible to deduce discharges except on the basis of one observation; but the discharge being observed for a given height of gauge, all others can be deduced readily, as the velocities will vary as $\sqrt{R}$; the other terms remaining constant. The drawing out of a Table, therefore, will be comparatively easy.

employment of every cubic foot of the water given into his charge, as he is for every Rupee of Government money which passes through his hands; and the keeping up of an account current (as it were) showing the half-yearly receipts and expenditure of water, is as essential as the keeping up of his Cash-Book. But without water-gauges and corresponding tables of discharges, he cannot arrive at a knowledge of either his receipts or his expenditure; and, consequently, both he and Government must remain in the dark as to the real results of his administration.

9. The observations most immediately requiring registration are—

I.—For the supply entering the Division; and

II.—For the supply passed off both to the Division next lower down (if there be one) and through tails and escapes;

and the Chief Engineer requests that Superintending Engineer will arrange to have this information obtained with regularity and with accuracy.

10. The difference between the aggregates of I and II will, of course, give the total expenditure of water in the Division. This total expenditure is made up of—

A.—The loss in the canal itself by evaporation and absorption,

B.—The loss in rajbuhas,

C.—The loss in water-courses, and

D.—The actual expenditure of water in irrigation.

And it is evident that it is the duty of the Executive Engineer to reduce the three items, A, B, and C, to the very lowest; but it is impossible for him even to know whether the measures he may adopt for this purpose are at all successful unless he has the means of recording and of comparing actual quantities.

11. Government of India has lately called for statistics of rajbuhas to be furnished annually, and the Chief Engineer has submitted a form for approval, and an application for the means of filling it in (establishment) if approved of. This will give us—

III.—The supply issued from the canal through rajbuha heads, and

IV.—The supply passed off to rajbuhas lower down (if there be any), and through rajbuha, tails, and escapes.

2. A table of discharges consists of four columns, showing—

I.—The height of water on the gauge to tenths of a foot, from zero to the highest possible rise on the gauge.

II.—The corresponding area of water-section to hundredths of a square foot.

III.—The corresponding mean velocity of the current in lineal feet per second to hundredths of a foot.

IV.—The corresponding discharge in cubic feet per second to hundredths of a cubic foot.

3. The Tables of Discharge for artificial channels can be worked out theoretically in the first instance, and then checked and perfected gradually by observations made whenever an opportunity offers.

4. The position for the gauge should be chosen with care: for, unless the bed and banks of the stream remain practically permanent at, and for some distance above and below, that position, the height of water on the gauge can give no accurate data from which to compute the corresponding areas, velocities, and discharges.

5. Every gauge should have its "referring bench-mark" on some permanent building, or else specially built, out of the reach of injury from floods, &c., so that if the gauge be disturbed, or even carried away, it may speedily be re-placed, or a new one set up with its zero on the same level as the old one.

6. Special care should be bestowed on the accurate registration of gauges in rivers and streams, at the season when they are lowest, or nearly so, and as it so happens that at this season the channel is not often altered by the action of floods, it is easy to compute the minimum discharge by the aid of the gauge register and one set of observations, which should always be taken when the river is as near its lowest state as can be conveniently managed.

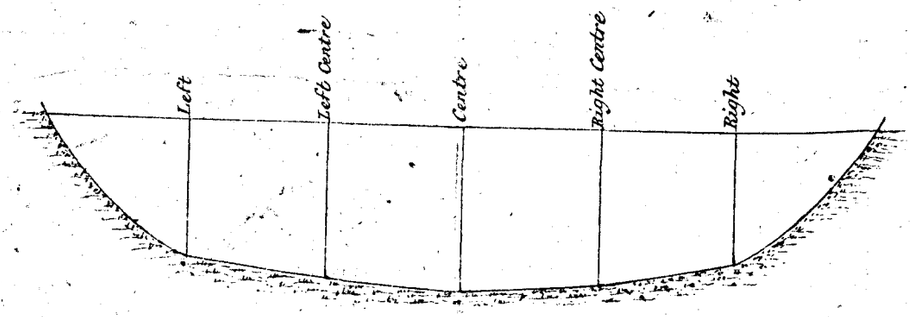
7. In the case of artificial channels, silt is the great obstacle to accuracy of results being obtained from water-gauges. It may, therefore, be useful to know that, in ordinary soil, neither cutting nor silting takes place with a mean velocity of from 2½ to 3 feet per second, that is, when the silt is of the ordinary kind, and not either gravel or shingle. Accordingly, an endeavour should be made to place the water-gauge where the mean velocity of the current ranges between the given limits. This can seldom be managed on rajbuhas, except in the neighbourhood of a fall. A point, a little up-stream from the crest of an open fall, and beyond the influence of the acceleration of velocity due to its proximity, is not a bad place for a gauge. If, however, the natural level of the water is liable to be interfered with by planking up, or by any other artificial obstructions of irregular action, such a position should be avoided.

8. With regard to canals, &c., Chief Engineer holds that each Executive Engineer in charge of an irrigating work is as responsible to Government for the proper economical

4. In order to ascertain the discharge by actual observation, a spot as near as possible to an existing *punsal* should be selected, where the disturbance of bank and bed has been only slight At this point, the section of channel should be taken by measurement, the depths being ascertained at equal intervals, say, at every 5 feet of width. If the section of the prolongation of the banks above water surface is also given, this one section will do for all the calculations or observations at this spot. The section, being obtained, will admit of the area and wetted perimeter being ascertained, whence the hydraulic mean depth can be deduced.

5. A distance of 100 feet, both above and below the site of section, should be measured along the canal bank, and strong pegs be driven into it at these points, thus giving a total length 200 feet, with the measured section in the centre. Two similar pegs should also be driven on the other bank of the canal opposite to the two first described.

6. The time of floatation of a light body will then be observed along this distance in seconds by means of a watch, which will determine the surface velocity, which multiplied by ·81 will give the mean velociety, and this latter multiplied by section of water, will give discharge in cubic feet per second. This timing must be taken in five points in the channel: one in the centre, and two others on each side, equi-distant between it and the bank, thus—



Five observations of velocity will be made at each point, thus giving 25 in all, the mean of which will show the average surface velocity at the point where the section is.

7. The first point is to stretch a rope tightly across the channel, marked off in 5 feet lengths by a 10-foot rod, pieces of coloured cloth being tied at each 5 feet. Then with a boat, the depths at each of these points can be ascertained, which will give the section of the Canal.

8. For timing the velocity, the simplest float will be a piece of "oopla," with a patch of whitewash on it, so as to make it easily distinguishable. Four flags should then be stuck up at the four pegs, and a man stationed at the upper and lower flags on the bank on which the Officer is; the float will then be let go where it is required, a little above the upper flag, so that it may acquire the velocity of the current before reaching that spot. On passing the flag, the man stationed there will cry out, and the Officer will note the time, and in passing the lower flag, the signaller there will likewise call out, and the time will be noted, from which the time of floatation will be ascertained, and the velocity per second can be deduced. The pegs should be left permanently in the banks, so that, in subsequent observations all that will be necessary will be to take the time of floatation between them, the section varying merely with the depth of water. It is requested that orders be issued that every Officer be directed, whenever he visits the spot, to take the velocity by actual observation; this will verify previous observations if the gauge is the same, or determine new velocities for any variation that may exist.

9. The annexed form of Table is to be adopted; the first entry being the result of actual observations, from which the Table can be completed in the first instance by results obtained from it as a datum; the column of actual or observed discharges being left blank to be filled up hereafter as observations may enable it to be done. As soon as the Table is filled with calculated discharges, a copy will be sent to this Office, and all future observations will be reported in order that it may be completed as information is gained.

10. In each division, these observations should be made as near the head as possible, above the first set of rajbuhas, and at the tail below the last set of rajbuhas, so that on knowing the discharge at both head and tail during the month, the expenditure of the division can be deduced.

11. In order, however, to ascertain correctly the expenditure in divisions, some corrections will be necessary; for instance, if escapes are opened, a similar procedure must be adopted for ascertaining their discharges, and in case of rajbuhas of a lower division being taken off above the lowest gauge of the division, their discharges must be entered, and be deducted from the total of the division. In the Revenue Report of the division for each half-year, the following information will be given:—

			C. ft. per second.
Discharge at head (Myapoor), average gauge	4·76	feet	= 5,220
Discharge at tail (Jaolee), " "	5·20	"	= 4,540
Difference ...			*680*
			C. ft. per second.
			0
Deduct loss by escapes			45
Right rajbuha, Meerut division, at Jaolee fall			50
Left rajbuha, Futtehgurh " "			— 95
			—
Total ...			585
			0
Add right rajbuha taken out from (next above) division			0 0
"		...	— —
Left "			585
Total ...			=

12. It is requested that great care may be taken in the preparation of the return of water expenditure in each division, as required. It may happen that local circumstances may make alterations necessary, but the above general instructions will show Officers what is

required. The actual discharges of the canal must, however, be taken at once, and the Table filled in the annexed form:—

Discharges of Ganges Canal (at Roorkee.)

Height of Gauge, Feet.	Area of Section, Square Feet.	Hydraulic Mean Depth, Feet.	By Observation.		Discharge, Cubic Feet per Second.	By Calculation.	
			Surface velocity V, feet per second.	Mean velocity ·81 V, feet per second.		Mean velocity feet per second.	Discharge, cubic feet per second.
	1	2	3	4	5	6	7
7·							
6·9	1,295·21	6·46	4·12	3·335	4,316·89	...	...
6·8							
&c.							
6·4	1,224	6·15	...	...	....	3·25	3,986·56
6·0							
5·9	1,147·5	5·82	...	...	...	3·16	3,630·69
5·8							
&c.							
5·							

Columns 1 and 2 can be filled in at once on sections being taken; 3, 4 and 5 will be filled as observations allow.

Columns 6 and 7 can be calculated, and should be filled in on calculation at once, and they will be verified by the entries of 3, 4, and 5, as they are obtained.

Nos. 11—12, dated 2nd May, 1866.

Memo. from—Lieut.-Col. J. H. Dyas, R. E., *Chief Engineer of Irrigation Works,*

To—*Supdg. Engrs., 1st and 2nd Circles, Irrigation Works, N. W. P.*

Requests that the punsauls in his Circle may be registered and sent in on sheets holding ten days (or one-third of a month) each, that is the first interval of each month to be from 1st to 10th inclusive, the second from 11th to 20th, and the third from 21st to end of month.

2. At the top, the full-supply Punsaul to be written with the corresponding discharge under it, and at the bottom the average-supply Punsaul for the ten days, with the corresponding discharge under it, as follows:—

Full supply	...	...	... { 5·60 / 2,060
1st	...	...	... 0·00
2nd	...	...	... 0·00
3rd	...	...	... 0·00
4th	...	...	... 0·00
5th	...	...	... 0·00
6th	...	...	... 0·00
7th	...	...	... 0·00
8th	...	...	... 0·00
9th	...	...	... 0·00
10th	...	...	... 0·00
Average	...	...	... { 4·32 / 1,485

No. 127 I, dated 26th August, 1867.

From—Colonel C. H. Dickens, R. A., *Secy. to Govt. of India, P. W. Dept.,*

To—*Under Secy. to Govt. of N. W. P., in the P. W. Dept., Irrigation Branch.*

I am directed to acknowledge receipt of your letter No. 559 I of 10th August 1867, and to state that the Governor General in Council entirely approves of the action taken, and instructions issued, by the Chief Engineer of Irrigation Works in the North Western Provinces, in the matter of keeping a record of the discharge, &c., of Canals of Irrigation.

No. 28 I.

GOVERNMENT OF INDIA.

PUBLIC WORKS DEPARTMENT.

IRRIGATION.

Simla, August 26, 1867.

Record of volume of water which enters Canals of Irrigation, that which is utilized, and that which escapes.

Read the following papers:—

Public Works Department Nos. 71—2 I, dated 11th June 1867.

Letter from the Government of the North Western Provinces, No. 559 I, dated 10th August 1867, and enclosures.

Public Works Department No. 127 I, dated 26th August 1867.

Order.—Ordered, that copies of these papers be forwarded, for information, to the Governments of Madras, Bombay, Bengal, and the Punjab.

William McCleary C. E., *Offg. Asstt. Secy.,*
for Secy. to the Govt. of India.

To
Secy. to the Govt of Madras P.W.D. (for information)
Irrigation branch

Pro: of Govt for October
3620

GOVERNMENT OF INDIA.

PUBLIC WORKS DEPARTMENT.

IRRIGATION.

To

The Secy to Govt 3620.

No. 129 I.

Dated SIMLA, *August* 26, 1867.

Received 25 Sept 67

Encl. &c. V

In regard to the record of volume of water which enters Canals of Irrigation, that which is utilized, and that which escapes.

encl 3050 - 1st Octr 1867.

Wm Muir

Circulate

3050

encl 3050 -

Commd to the Supt Engrs for information -

H.

Fort St George
1st Octr, 1867

J E —
" Capt Kennedy
Rec'd 7/10/67

75
9

Oct 9—10

encl 25th Septr 1867 Bk 265